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PATENT—PCT, IPEA/US

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE
(kernco01.006)

Applicant:	Kernco, Inc.	**Paper No.:**
Application No:	PCT/US04/19695	**Group Art Unit:** ISA/US
Filed:	18 June 2004	**Examiner:** Michael B. Shingleton

Title: *Determining the frequency modulation index of a laser in a CPT frequency standard*

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Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Response to a written opinion under PCT Rule 66.3

Summary of the prosecution

A *Demand for an international preliminary examination* under Chapter II of the PCT was made in the above application on 12 Jan. 2005; a *Written Opinion of the International Searching Authority* was mailed on 1 Mar. 2005. In the written opinion, Examiner found that the subject matter of claims 1-20 was disclosed in U.S. Patent 6,201,821, Zhu, et al., *Coherent population trapping-based frequency standard*, issued 13 March 2001 (henceforth "Zhu"), and that the subject matter of claims 21-23 did not constitute an inventive step over Zhu. A time limit of 3 months from the mailing date of the written opinion was established for a response to the written opinion. The response follows.

Amendment of claim 21 under Article 34 PCT: Please replace page 18 of the application with the following replacement page 18 containing an amended claim 21:

2   the CPT frequency standard automatically performs the method of claim 17

3   upon initialization.

1   **20.** The method set forth in claim 18 wherein:

2   the CPT frequency standard automatically performs the method of claim 17

3   during normal operation.

1   **21.** A CPT frequency standard comprising:

2   a frequency-modulated current source for a laser;

3   an alkali metal vapor cell through which light from the laser passes; and

4   a control processor that receives a digitized signal that indicates ~~variations in~~

5   ~~the amount of light which is transmitted by the vapor cell~~the absorption spectrum of

6   the alkali metal vapor,

7   the control processor determining a current modulation index from the digitized

8   signal and controlling the power of the frequency modulation in the current source to

9   produce the desired modulation index.

1   **22.** The CPT frequency standard set forth in claim 21 wherein:

2   the control processor controls the power of the frequency modulation in the

3   current source to produce the desired modulation index upon initialization of the CPT

4   frequency standard.

1   **23.** The CPT frequency standard set forth in claim 21 wherein:

2   the control processor controls the power of the frequency modulation in the current

3   source to produce the desired modulation index during normal operation of the CPT

4   frequency standard.

Remarks

The amendment to claim 21

The amendment to claim 21 gives that claim the limitation "a control processor that receives a digitized signal that indicates the absorption spectrum of the alkali metal vapor". The claim as amended is supported at page 8, line 29-page 9, line 5.

What Applicants are claiming

Applicant's patent application is directed to a technique for determining the modulation index of a laser whose light passes through an alkali vapor cell by the absorption spectrum of the alkali metal vapor. The absorption spectrum is detected by a photodetector that receives the light which passes through the alkali vapor cell. As set forth in detail at page 6, line 31-page 8, line 12, the form of the output signal from the photodetector is determined by the absorption spectrum of the alkali metal vapor. See in this regard page 7, lines 25-35 and the theoretical discussion of the absorption phenomenon beginning at page 9, line 30. As now amended, all of Applicant's independent claims specifically point out that the modulation index of the laser is determined "from the absorption spectrum of the alkali metal vapor."

The disclosure of Zhu

The disclosure of Zhu is well-described by the *Abstract:*

> The frequency standard comprises a quantum absorber, a source of incident electro-magnetic radiation, a detector, a frequency difference controller, a spectrum controller and a frequency standard output. The quantum absorber has transitions including a first transition between a first lower quantum state and an upper quantum state, and a second transition between a second lower quantum state and the upper quantum state. The first transition and the second transition have energies that correspond to frequencies of [ohgr] (1) and [ohgr] (2), respectively. The lower quantum states differ in energy by an energy difference subject to a total a.c. Stark shift. The source of incident electro-magnetic radiation is arranged to irradiate the quantum absorber. The incident electro-magnetic radiation includes main frequency components at frequencies of [OHgr] (1) and [OHgr] (2), equal to [ohgr] (1) and [ohgr] (2), respectively, and additionally includes additional frequency components collectively having a spectrum. The detector is arranged to receive electro-magnetic radiation from the quantum absorber and generates a detection signal in response to the received electro-magnetic radiation. The frequency difference controller controls the source to generate the main frequency components with a difference in frequency that obtains an extremum in the detection signal. The extremum indicates that the difference in frequency

corresponds to the energy difference. The spectrum controller sets the spectrum of the additional frequency components to reduce the magnitude of the total a.c. Stark shift. The frequency standard output a frequency standard signal related in frequency to the difference in frequency.

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As clearly set forth in the *Abstract,* what Zhu is concerned with is adding additional frequency components to the light which passes through the quantum absorber in order to reduce the magnitude of the a.c. Stark shift and thereby sharpen the extremum which is detected by the detector. There is no mention whatever in Zhu of the *absorption spectrum* of the quantum

10   absorber, let alone of its use to determine the modulation index of the laser source.

Examiner's arguments

In his explanation of why Zhu discloses what Applicant is claiming, Examiner refers Applicant to col. 8, around line 30, col. 9, lines 17-48, and col. 11, around lines 47-50. As for col. 8, line

15   30, that merely indicates that the detector may detect any of "the unabsorbed portion of the incident light transmitted through the quantum absorber, the fluorescent light generated by the quantum absorber in response to the incident light, and the coherent emission generated by the quantum absorber in response to the incident light". Col. 9, lines 17-48 describes how the light produced by the laser is modified to reduce the a.c. Stark effect.; Col. 11, lines 45-50 sets

20   forth that the value of the modulation index that minimizes the Stark shift depends in part on the operating temperature of the quantum absorber. As would be expected from the *Abstract* cited above, *none* of the cited locations disclose anything whatever about using the *absorption spectrum* of the quantum absorber to determine the modulation index.

25   Examiner is apparently aware of the difficulties posed by Zhu, for he concludes his argument regarding the novelty of claims 1-20 as follows: "Given that the alkali vapor cell is composed of the same material namely rubidium . . . the determining of the modulation index via the ratios of the minima including the "satellite minimum" is inherent in Zhu '821 for the alkali vapor cell will have the same minima as that of the instant application". Applicant's claimed

30   technique is of course based on the physics of passing laser light through an alkali metal vapor cell, and will therefore work in Zhu, but that does not mean that Zhu inherently discloses the technique. What Zhu discloses is how to tinker with the modulation index to minimize the a.c. Stark shift; the reference discloses nothing at all about determining what the modulation index *is*, and as might be expected from that fact, also discloses nothing about using the "absorption

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